PATENT SPECIFICATION

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(54) HEAT EXCHANGER FOR LIQUID HEATERS

(71) We, ROBERT BOSCH GmbH, a German company of Postfach 50, 7 Stuttgart 1, Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a heat exchanger for liquid heaters, especially for gas operated water heaters operating according to the continuous circulation principle; and to a liquid heater employing the heat exchanger.

Such a water heater comprises a heat exchanger in the form of an assembly of laminations through which a plurality of pipes are guided, and fixed thereto, parallel with another, the pipes conducting the liquid which is to be heated. The ends of the pipes, which protrude from the assembly, are rigidly joined together by way of respective elements which have a different coefficient of thermal expansion or are submitted to a temperature which differs from that of the laminations.

An apparatus of this type is disclosed in German Offenlegungsschrift 25 05 765, in which the laminations are formed with completely smooth surfaces apart from rims on the holes for the pipes and apart from bevelled edge strips; and the lamination assembly is enclosed in a frame which reinforces the assembly and is provided with a surrounding flange for placing the heat exchanger upon a combustion chamber. During the heating of such heat exchangers, relatively high tangential stresses are produced at the pipe clamping points when the lamination material and the sheet material of the frame have different thermal expansions or different temperatures. In addition there are torsional stresses which are produced by the laminations expanding to a greater extent on the underside facing the burner than on the upper side, and thereby they tend to become twisted with their ends pointing upwards. In unfavourable cases, these stresses which occur periodically may cause the material of the pipes to fracture at their clamping points.

There is provided by the present invention a heat exchanger for liquid heaters, comprising a plurality of pipes to conduct the liquid to be heated, the pipes being guided and fixed parallel with one another, and a plurality of laminations each bearing a central hole, there being a set in respect of each pipe; each pipe passing through the central hole of the laminations of the respective set with the laminations being secured to the pipe to lie normal to the line of the pipe and spaced along the length thereof but to leave a portion at each end of the pipe free of laminations; the ends of the pipes being rigidly joined together by respective elements having a different coefficient of thermal expansion and/or assuming a different temperature in use, in comparison with the laminations, wherein the laminations are provided with bending folds in areas between the pipes to balance the differential thermal expansion of the laminations and said elements.

By comparions with the known apparatus, the heat exchanger of the invention has the advantage that the mechanical stresses are reduced so that the fatigue limit of stress of the materials used is not exceeded, while the laminations still retain an adequate rigidity.

The construction of the laminations used in the present invention ensures that the internal cross-section of flow on the exhaust gas side of the heat-exchanger does not alter, as would be possible with a fixed separation between the pipes because of internal stresses or an effect resulting from external force. The hygiene of the exhaust gas could thus be inadmissibly affected because the secondary air intake during a combustion process is determined by the pressure loss in the narrowest cross-section of the assembly of the laminations on the exhaust gas side above of the heat exchanger, which produces the chimney effect. The efficiency, i.e. the heat absorbed by the heat exchanger, would also alter because of a change in the secondary air intake, because the air number "2" affects the combustion temperature and therewith the mean effective temperature difference and the exhaust gas volume

Embodiments of the invention will now be

described, by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a partial sectional view of a gas-heated continuously circulating water heater comprising a combustion chamber and a heat exchanger formed as an assembly of laminations;

Figure 2 is a front view of a lamination;

Figure 3 is a side on view of a lamination;

Figure 4 is a fragmentary view of an alternative form of lamination, and

Figure 5 shows the tendency of the laminations to twist upwards during heating.

Referring to Figures 1 to 3, the heat exchanger 11 located at the upper outlet side of a combustion chamber 10 has an assembly of laminations 12 through which a plurality of water-conducting pipes 13, parallel with one another, are passed. The ends of the pipes 13 are soldered in plates 14 which are soldered to covers 15 which form collecting chambers 16 between the covers and the plates 14. A feed pipe 17 opens out into one collecting chamber 16; a discharge pipe 18 is connected to the other collecting chamber. The feed pipe 17 and discharge pipe 18 are soldered in the covers 15.

The assembly of laminations 12 comprises individual chromium steel laminations 20 (Figure 2) which are provided with holes 21 for the passage of pipes 13. Raised collars or rims 22, with which the laminations are soldered onto the pipes 13, are formed at the edges of the holes. The collars 22 and the lateral edges 23 of the laminations, which are bent to the level of the collars, determine the gap *a* between laminations. The laminations 20 have a different coefficient of thermal expansion and in use are submitted to a different temperature compared with the plates 14 and the covers 15.

Between the holes 21, the laminations are provided with bending folds 26 which have a corrugated cross-section and run from the upper lamination edge 27 to the lower bending edge 28 facing the burner of the apparatus. The folds have a depth, measured at right angles to the plane of the lamination, substantially equal to the gap *a* between adjacent laminations. Recesses in the form of closed slots 30 are provided in the vertex of the bending folds 26, each to leave two bars 31 and 32 between the slots and the respective lamination edges 27, 28. The lower lamination edge 28 is taken in between the holes 21 so that as uniform a heat flow density as possible is obtained in these lamination regions.

During operation of the heat exchanger, the chromium steel laminations 20, which are resistant to corrosion by the heating gases expand to a lesser degree than the plates 14 and covers 15 which are made of copper. This produces stresses on the pipes 13 which are taken up by the resiliently deformable bars 31, 32 so that only slight tangential stresses occur at the clamping points of the pipes 13 in the plates 14. On the other hand, the bars 31, 32 also provide the laminations with sufficient rigidity that no difficulty arises in inserting the laminations into the assembly tool.

During operation of the heat exchanger, an upward twisting force is applied to the laminations, besides the rectilinear expansion. This tendency to twist upwards is produced because the laminations at the lower edge 28 reach a temperature of 300 to 400°C, whilst the temperature at the upper edge 27 of the laminations only rises to approximately 150°C. The lamination 20[1] shown in Figure 4 differs from the lamination 20 shown in Figure 2 in that two slots 35 and 36 are punched in each bending fold 26, the upper slot 35 of these two slots opening out into the edge 27 of the lamination. Formed between the slots 35 and 36 is a bar 38 whch has a deeper seating than the bar 31 of the lamination 20 shown in Figure 2. With free deformation on the assumption of a linear temperature distribution, a lamination of this design has in fact exactly the same upward twist as the lamination 20, but the restoring moments generated by the lamination are substantially smaller. Figure 5 shows that, with such an upward twist, the holes 21 in the lamination become distorted and displaced relative to the pipes 13 with a tendency which increases towards the end of the lamination. Torsional stresses and additional tangential stresses are thus exerted upon the clamping points of the pipes 13 which, in the case of the lamination shown in Figure 4, are reduced according to the substantially smaller restoring moments. Instead of providing two slots in each bending fold as in Figure 4, three aligned slots could be provided with the outer two forming open slots in the manner of slot 35 and the remaining slot forming a closed slot lying between the two open slots.

WHAT WE CLAIM IS:—

1. A heat exchanger for liquid heaters, comprising a plurality of pipes to conduct the liquid to be heated, the pipes being guided and fixed parallel with one another, and a plurality of laminations each bearing a central hole, there being a set in respect of each pipe; each pipe passing through the central hole of the laminations of the respective set with the laminations being secured to the pipe to lie normal to the line of the pipe and spaced along the length thereof but to leave a portion at each end of the pipe free of laminations; the ends of the pipes being rigidly joined together by respective elements having a different coefficient of thermal expansion and/or assuming a different temperature in use, in comparison with the laminations, wherein the laminations are provided with

bending folds in areas between the pipes to balance the differential thermal expansion of the laminations and said elements.

2. A heat exchanger according to claim 1, wherein the depth of the bending folds, measured at right angles to the plane of the laminations, is equal substantially to the gap between adjacent laminations.

3. A heat exchanger according to claim 1 or 2, wherein the laminations are provided with recesses in the region thereof at which the bending folds are formed.

4. A heat exchanger according to claim 3, wherein said recesses comprise closed slots.

5. A heat exchanger according to claim 4, wherein the slots lie in the direction passing between the edges of the lamination, which in use respectively lie uppermost and lowermost.

6. A heat exchanger according to claim 5, wherein the recesses are constituted solely by said slots.

7. A heat exchanger according to claim 4 or 5, wherein two or three slots aligned across the width of a lamination are provided at the bending folds thereof, one slot of the two slots or the two outer slots of the three slots, as the case may be, being open towards the lateral edge of the lamination.

8. A heat exchanger according to claim 7, wherein, in the case of two aligned slots, the or each slot which is open towards the edge of the lamination, is located in the bending fold on the side of the lamination remote from the burner.

9. A heat exchanger according to any of the preceding claims for gas/water heaters, wherein the edge of each lamination in use facing the burner, is taken-in in the regions located between the pipes.

10. A heat exchanger substantially as hereinbefore described with reference to Figure 1 and to Figures 2 and 3 or Figure 4 of the accompanying drawings.

11. A liquid heater whenever incorporating a heat-exchanger according to any of the preceding claims.

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1592125 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

Fig.1

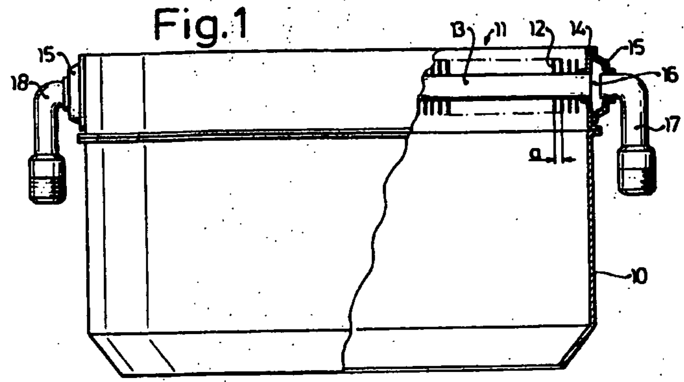

Fig. 2

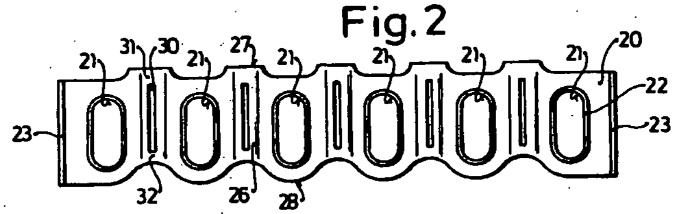

Fig.3

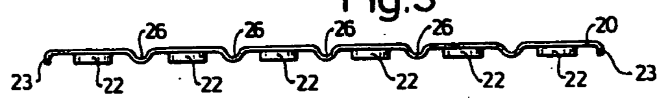

Fig.4

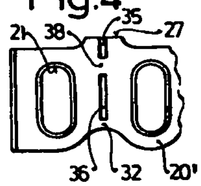

Fig.5